



Investigation of Dairy Cattle Concentrate Quality, Traceability & Handling Practices Adopted by Farmers – A Case Study Conducted in Sri Lanka

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Keywords—dairy cattle concentrate, handling practice, moisture content, product information, traceability.

Abstract— This study was done in selected dairy farms in Central Province of Sri Lanka. As the Stage 1, 67 farms were selected and type, quality, traceability and farm level handling practices of different dairy cattle concentrates were identified. Analyzed results were; scale of dairy farming and farming method used, dairy cattle concentrate types used, product information & packaging and handling practices. Major findings were; average number of cows per farm was 3.1, concentrate types identified were coconut oil cake and formulated dairy cattle concentrate, 75.9% of the coconut oil cake products on the market had an unknown origin, all the coconut oil cake products had no product details and none of the farmers used total mix rations to feed their animals.

For the Stage 2, 64 dairy farms were selected. Moisture content of the dairy cattle concentrates were analyzed with respect to the storage method and they were statistically analyzed. Out of all the farms, 37.5% used coconut oil cake and 62.5% used formulated dairy cattle concentrates as their dairy cattle concentrate. In coconut oil cake uses, there was a significant difference ($P<0.05$; $P=0.003$) of moisture content between products stored on pallets without sealing well and well-sealed products on pallets and there was no significant difference ($P>0.05$; $P=0.159$) between the moisture contents with respect to the storing methods used to store formulated dairy cattle concentrates. Hence, this study provides an indication that coconut oil cake requires careful sealing and storing since it has a greater tendency to absorb atmospheric moisture.

I. INTRODUCTION

Over the past few decades, world cows' milk production has increased significantly. Milk yield per cow has increased about 2% per year. In 1980, milk yield of an average cow was about 5,500kg per year/ 15.06kg per day and in 2005, it was about 8,500kg per year/23.29kg per day (Eastridge et al., 2006). In 2017 world cows' milk production was

increased to 828 million tons (FAO 2018) and the dairy cow population in 2016 was recorded as 278,482,840 (AHDB 2018).

Even though the world's dairy industry has developed rapidly over the past few decades, the present situation of the most developing countries is not satisfying. In 2006, Sri Lankan cow milk production was 164,862,200 liters and the

dairy cattle population was about 1,214,000 (Perera & Jayasuriya., 2008) which resulted 136 liters per year/ 0.357 liters per day average milk yield per cow. Therefore, local dairy industry in Sri Lanka is not sufficient to fulfill needs of its population. Sri Lanka had 290,628 registered dairy all farms around the country in 2015. From those, 36,981 dairy cattle farms were recorded in the Central Province and the milk production was 21,028,300 liters (DAPH 2015). Hence, the central province in Sri Lanka can be considered as the hub of milk supply in the country, emphasizing the need of analyzing the efficiency of dairy production and dairy farming practices in the central province.

Studies reveal that the main three aspects of improving milk composition are nutrition and management, cow genetics and dairy processing methods (Walker et al., 2004). However, cow nutrition itself is the only way to alter milk composition in a short period of time. It is known as the most suitable way to meet dynamic market demands (Ferland et al., 2018).

Dairy cattle concentrates are playing an important role in dairy cattle nutrition. Cattle concentrates are being fed to cows to fulfill all the basic nutritional needs that are required for efficient milk producing. Mainly they provide a considerable amount of energy needed for the metabolism. Also they are low in fiber content and the protein content can be low, medium or high (Isher et al., 1914). Some studies have reported that milk composition can be altered by feeding the cow with different grains. Casper et al., (1990) declare that the milk yield of cows fed with corn grain is higher than the cows fed with barley. Also, high moist corn has a greater impact on milk yield than the dry ground corn (Wilkerson et al., 1997). Providing total mix rations are proven to increase the milk performances such as milk yield, protein content, fat concentration etc., than feeding the concentrates separately (Burkholder et al., 2004; Ferland et al., 2018; Istasse et al., 1985; Kennelly 1996; Kolver & Muller et al., 1998). Hutzens (1996) states that providing total mix ration meal twice a day would significantly increase the milk performance. A study done by (Jin et al., 2007) revealed milk yield and the milk protein can be significantly ($P<0.05$) increased when the cows are supplemented with palm kernel cake in 10 – 18%. However same study proclaimed supplementing cows with palm kernel cake had no significantly ($P>0.05$) effect on the milk fat, total milk dry matter and lactose content.

In advance, some of the latest studies revealed that introducing microalga spores to the cattle diet can increase the quality of the milk properties. Morgan et al., 2019 declare that supplementing dairy cattle with *Aurantiochytrium limacinum* in the meal form can successfully enrich the milk with docosahexaenoic acid (DHA) in 84 days. According to the study, level of supplementation have

no effect on the milk yield and the other milk properties (fat, protein, lactose content).

Therefore, this study was conducted to investigate three main factors in the local dairy farm community. One reason is to investigate the dairy cattle concentrate quality, traceability, handling and feeding practices followed by farmers; in aim to provide suggestions regarding quality, traceability, handling and feeding practices to the farmers. Because still the majority of the farmer community has not been provided with adequate basic scientific knowledge about enhancing the cattle nutrition, which is the only method to improve the composition and the yield of milk in a short period of time. On the other hand, there are adequate studies have conducted island wide to enhance the finish good characteristics of dairy products. For example, recently conducted study by (Samarathunga et al., 2020) developed a drinking yoghurt fortified with Calcium and Zinc also having higher antioxidant capacity by using plant extract rather than using pharmaceutical ingredients. However, since these type of studies are based on dairy products, having good raw milk with better composition will have a major positive impact on the study and the final product. Therefore, the actual state of the farmers' knowledge regarding dairy cattle concentrates, their usage frequency, efficacy and handling practices can be investigated.

Second reason is to investigate the ongoing food handling and safety practices carrying out by the dairy cattle manufacturers and the responsible parties. Because due to the importance of the dairy cattle concentrates quality parameters and safety guidelines have been legislated (Animal Feed (Amended) Act No 15 of 2016 Parliament of the Democratic Socialist Republic of Sri Lanka ; Codex Alimentarius Commission 2008).

Final reason is to investigate the moisture content of the dairy cattle concentrates with respect to their storage method at the farmer level. Because farmer level handling practices are as much as important as the handling practices done at the manufacturer level to provide animals a safer and nutritive dairy cattle concentrate product.

This study model maybe useful for any other similar country, who wish to evaluate the conditions/ practices of dairy farming, in aim to upgrade the efficacy and quality of their dairy production.

II. MATERIALS AND METHODS

The study was conducted in selected dairy farms in Central Province of Sri Lanka from December 18th of 2017 to April 30th of 2018. Areas selected were Peradeniya, Gampola, Duluwa, Nawalapitiya, Pussellawa, Duluwa, Kothmale and

Atabage (Figure 1). The overall research conducted was divided into two stages; Stage 1 was conducted as a survey; to identify the quality, traceability and farm level handling practices of dairy cattle concentrates. Stage 2 was conducted to investigate the moisture levels of different dairy cattle concentrate types that were being used in the selected dairy farms of the area with respect to their storage conditions.

2.1 Stage 1 – Investigation of quality, traceability and farm level handling practices of dairy cattle concentrates

67 dairy farms were selected for the study by simple random sampling. Data was collected through an open question questionnaire. Collected information included; farm location, no of cows available in a farm, cow breed, farming method, dairy cattle concentrate type used, brand of the dairy cattle concentrate, purchasing place, product information, type of the packaging material, number of dairy cattle concentrate meals given per cow, dairy cattle concentrate quantity given per cow and method of serving. Product details were collected to test whether the industry was obeying the regulations (Sri Lankan Animal Feed Act 2016). Data collected regarding the product information were; availability of Manufacturer's details, Batch number details, manufactured date and expire date details. Minitab 17 software was used to analyze the data obtained.

2.2 Stage 2 – Investigation of the moisture level of dairy cattle concentrate types with respect to the storage method at the farm level

64 dairy farms were selected for the study by simple random sampling. Dairy cattle concentrate samples which were

collected from the farms and were projected to test the moisture contents. Samples were collected to airtight bags. Recorded data were; dairy cattle concentrate type that is being used and the storage method practiced at the farm. To analyze moisture content, 2g of dairy cattle concentrate samples were taken and the weight was recorded (analytical balance; ABS 220-4, Max 220g, d=0.0001g). Then the sample was dried at 100°C of temperature under 100 mm/Hg (moisture oven; model: B35535 S Electron Italy) until obtained a constant weight. Moisture content was measured through the weight loss percentage (AOAC 2018). This process was triplicated and mean value was taken as the final moisture content of a dairy cattle concentrate sample. Minitab 17 software was used to analyze the data obtained.

III. RESULTS

3.1 Stage 1 – Investigation of quality, traceability and farm level handling practices of dairy cattle concentrates

Scale of dairy farming and farming methods used: Mean value of 3.1 No of cows per farm was obtained with a standard deviation of 5.2. Minimum value was 1 and the maximum value was 40. In the selected area, 89.55% of the farms did not have more than 4 dairy cows and only 2.98% of the farms have more than 10 cows (Figure 1). 16.42% of the farms were using the “Semi-Intensive Farming Method” and 83.58% of the farms were using the “Intensive Farming method”. None of the farmers were using “Extensive Faming Method”.

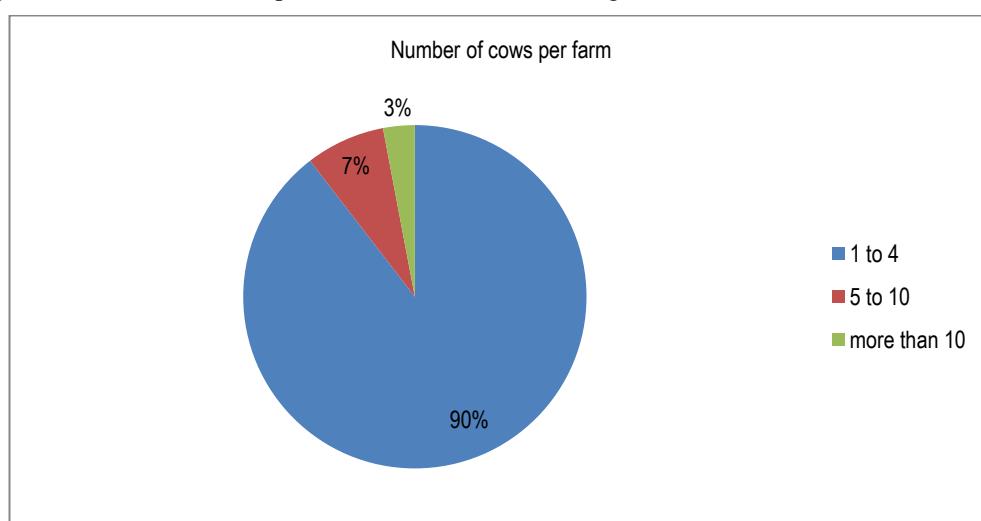


Fig.1: Number of cows per farm

Dairy cattle concentrate types used and purchasing place: One of the two main dairy cattle concentrates identified was coconut oil cake. These products were purchased from six different retail shops available in the area. Five out of six of these shops have no link with the coconut oil cake producing companies and only one shop has a link with the

producer. 43.3% of the farmers were using coconut oil cake as their cattle concentrate (Figure 2).

Other dairy cattle concentrate identified was formulated dairy cattle concentrate. Formulated concentrates were provided not only as a protein source, but to fulfil all

nutritional requirements that is not provided through forages. Under formulated dairy cattle concentrates, five brands were identified. All the formulated dairy cattle concentrates were purchased from authorized retailers. Therefore, the shops had a direct link with the formulated dairy cattle concentrate producing companies. Overall, 6.7% of the farmers were using formulated dairy cattle concentrates as their cattle feed (Figure 2).

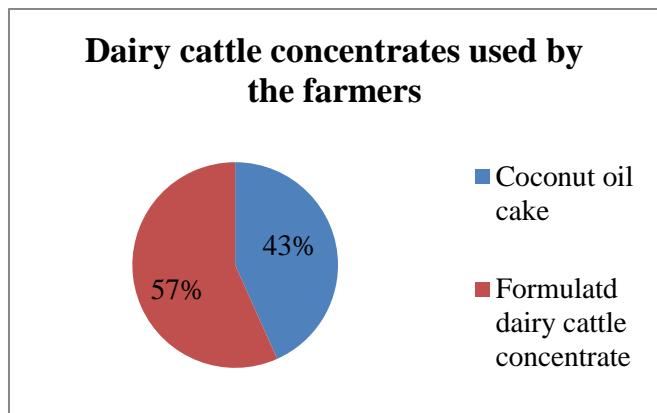


Fig.2: Types of dairy cattle concentrates used by the farmers

Product information and packaging: Considered product details were manufacturer's details, batch number records and manufacture and expire date information. Manufacturer's details of 75.9% of the coconut oil cake products that were supplied to the market are from unknown origins. Origin of the remaining 24.1% coconut oil cake products were known by the retailers (Figure 3 & Figure 4).

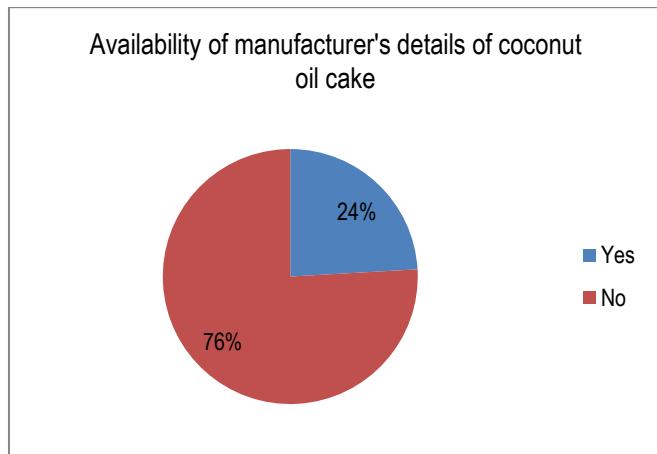


Fig.3: Availability of manufacturer's details; coconut oil cake products

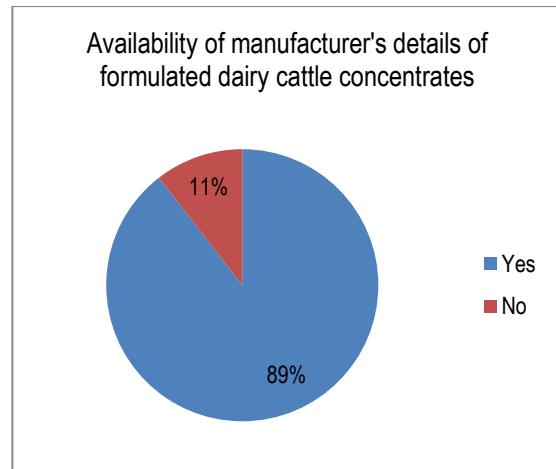


Fig.4: Availability of manufacturer's details; formulated dairy cattle concentrates

However, the manufacturer's details were not available on those products or labels either. Hence, 100% of the products contain no manufacturer's details on the product or on the labels. Results obtained for formulated dairy cattle concentrates revealed, 89.5% of the products contained manufacturer's details. Only 10.5% of the products did not contain manufacturer's details (Figure 3 & Figure 4).

Under Batch Number details and nutrition details: none of the coconut oil cake products contained Batch Number records and nutritional details. But, 89.5% of the formulated dairy cattle concentrates contain information on Batch Number records and nutritional details.

All the formulated dairy cattle concentrate products contain manufacture date and expiry date information. However, none of the coconut oil cake products contained manufacture date or expire date information.

None of the coconut oil cake products contained a packaging. On the other hand all the formulated dairy cattle concentrates contained a packaging material. Nylon was used to pack all the formulated dairy cattle concentrates.

Handling practices: When considering about the average number of meals given for a cow per day, coconut oil cake users have fed their cows an average of 1.93 ± 0.37 meals per day. Formulated dairy cattle users have fed their cow an average of 1.66 ± 0.48 meals per day (Table 1).

An average amount of 2.64 ± 1.13 kg coconut oil cake was fed to a cow per day. On the other hand, an average amount of 3.30 ± 2.11 kg of formulated dairy cattle concentrates were fed to a cow per day (Table 1).

Table 1: Farm level handling practices of dairy cattle concentrates

Dairy cattle concentrate type	Average daily number of meals per cow	Average daily quantity per cow
Coconut oil cake users	1.93±0.37	2.64±1.13kg
Formulated dairy cattle concentrate users	1.66±0.48	3.30±2.11kg

According to the results obtained for the feeding methods, 100% of the farmers have fed their concentrates separately. None of the farmers have used Total Mix Ration methods.

3.2 Stage 2 – Investigation the moisture level of dairy cattle concentrate types with respect to the storage method at farm level

As identified in stage 1; all farms were using by-product feeds and formulated dairy cattle concentrates as cattle feed. Under by product feeds, was all farms were using coconut oil cake.

Overall, 37.5% were using coconut oil cake as their dairy cattle concentrate in selected dairy farms. Three different storage methods were found at the farms that were using coconut oil cake. They were; storing concentrates on the floor without sealing, storing concentrates on wooden pallets without sealing and storing concentrates on the pallets well-sealed. According to the moisture analysis results, moisture percentages (W/w %) of concentrates are as shown in the table 2;

Table 2: Moisture levels of coconut oil cake with respect to storage conditions

Storage practice	Percentage of farms	Average moisture level
On the floor- without sealing	25.0%	0.0642±0.01g/g
On pallets- without sealing	58.3%	0.0815±0.01g/g
On pallets, well-sealed	16.7%	0.0451±0.01g/g

According to the results, moisture contents are significantly different ($P<0.05$; $P=0.003$) between products that were stored on pallets without sealing well and well-sealed products stored on pallets. Therefore, moisture content of coconut oil cake products can be determined as dependent on the storage condition.

Percentage of farmers who were using formulated dairy cattle concentrates were 62.5%. They were practicing four storage methods. They were; storing concentrates on the floor without sealing, storing concentrates on the floor well-sealed, storing concentrates on the pallets without sealing and storing concentrates on the pallets well-sealed. Moisture analysis results are as shown in the table 3;

Table 3: Moisture levels of formulated dairy cattle concentrates with respect to the storage conditions

Storage practice	Percentage of farms	Average moisture level
On the floor without sealing well	40.0%	0.0967 ±0.0g/g
On floor, well-sealed	2.5%	0.1098g/g
On pallets without sealing well	15.0%	0.0943±0.01g/g
On pallets, well-sealed	42.5%	0.1054±0.01g/g

There was no significant difference ($P>0.05$; $P=0.159$) between the moisture content with respect to the four storing methods used to store formulated dairy cattle concentrates. Hence, moisture content of the formulated dairy cattle concentrates maybe independent on the storage condition. One of the reasons for not having the moisture absorption impact on formulated dairy cattle concentrates can be due to the good packaging practices done by the manufacturers.

IV. DISCUSSION

4.1 Stage 1 – Investigation of quality, traceability and farm level handling practices of dairy cattle concentrates

Scale of dairy farming and farming methods used: Mean value of 3.1 No of cows per farm was obtained with a standard deviation of 5.2 for this study. Mean value of cows per farm obtained was equivalent to the global value of number of cows per farm which is also 3.1 (IFCN 2017). Since Sri Lanka is a developing country, average dairy cow per farm value is less. Registered dairy cattle farms reported in 2017 were 332,335. Total no of dairy cows reported in 2017 was 642,683, which elicits average number of dairy cows per farm as 1.93. In the Central Province, number of registered farms were 40,160 in 2017 and the dairy cows available were 59,816 which results an average number of cows per farm as 1.49 (DAPH 2017). However in the selected areas, average number of dairy cows per farm is higher than the values reported for the Central Province and for the whole country.

Most popular farming method observed among the farms in this study was the intensive farming method. In the Central Province of Sri Lanka; intensive, semi-intensive and extensive farming method practicing farms in 2017 were 42%, 45% and 13% respectively (DAPH 2017). The number of farms practicing intensive farm management system is higher than the other two methods. High altitude and the slope lands are the main reason for obtaining a higher number for intensive farm management system practicing farms. Austria; being a prime dairy producer in the world; has moved to Intensive Farming from Extensive Farming Method due to its reliability and efficacy. Current results reveal that farms using intensive method in Austria are around 80% to 85% and the farms using extensive method are 15% to 20% (Knaus 2016).

Dairy cattle concentrate types used and purchasing place: Isher et al (1914) revealed that there are mainly three types of concentrates available. They are cereals, plant or animal protein sources and by-product feeds. However, in selected farms for this study; cows were not given any cereals as a concentrate in the area. Either plant or animal based protein sources were not given directly to the cows.

Kavanagh (2016) proclaimed that dairy cattle concentrates can be divided into two main categories. They are energy feeds and protein feeds. According to the results obtained through the study, two main dairy cattle concentrate categories were identified. They were “by-product feeds” and “formulated dairy cattle concentrates”. Under by-product feeds, solely used product by local farmers was “coconut oil cake”. By-product feeds are usually used for ration formulation. Some by-products contain high-energy and/or high-fat. Hence, they can be used to balance the nutrient composition of rations (Isher et al., 1914). However in selected farms, by-product feeds were being given to the cows as straights. None of the farmers used coconut oil cake to formulate rations.

Product information and packaging: Even though coconut oil cake product was lack in product information, Sri Lankan Animal Feed Act 2016 reveals that the composition of the feed must be indicated as percentage by weight or if the product is a liquid composition must be indicated in grams per litre (Sri Lankan Animal Feed Act 2016).

Codex Alimentarius Commission (2004) has proclaimed under good animal feeding practices; in order to inform animal feed users to handle, store and use properly, the product information shall be stated on the animal feed packaging material clearly. Information that shall be stated are; information about the species or category of animals that the feed is intended, the purpose for the feed is intended, a list of feed ingredients, including appropriate reference to additives in descending order of proportion, contact

information of manufacturer or registrant, registration number if available, directions and precautions for use, lot identification, manufacturing date and expiry date. Also the same document states that the animal feed industry shall practice proper record keeping prior to trace-forward and trace back.

About 75.9% of the coconut oil cake products observed in the study contained no manufacturer's information, product information on their labels and traceability record details. On the other hand, majority of the dairy cattle concentrates consisted with product details on their labels.

Handling practices: Results obtained for the feeding quantities per cow per day reveal that the farmers who are using formulated dairy cattle concentrates were feeding their cows with larger portion sizes of concentrates than farmers who were using coconut oil cake. FAO; Harris (1992) states that the nutrient requirements of the dairy cows change according to the weight of the animal. However, none of the selected farmers have used a computation method to calculate the nutritional requirement of the cows in order to feed them to overcome nutrition deficiencies.

Even though none of the farmers were using total mix rations, studies have elicited that providing Total Mix Rations have high milk performances such as higher milk yield, protein content, fat concentrate etc, than feeding the concentrates separately (Burkholder et al., 2004; Ferland et al., 2018; Istasse et al 1985; Kennelly 1996; Kolver et al., 1998). Hutzens (1996) have found that the milk performances can be increased by feeding the cows twice a day by using total mix ration method.

4.2 Stage 2 – Investigation the moisture level of dairy cattle concentrate types with respect to the storage method at farm level

Results obtained through stage 2 provides an indication that coconut oilcake requires careful sealing and storing since it has a greater tendency to absorb atmospheric moisture rapidly. Overall, moisture absorption levels of formulated dairy cattle concentrates are not that dependable on sealing and storage methods. Studies have revealed that the storage conditions, storage time, substrate condition and high temperatures can lead to fungal growth and synthesis of aflatoxins (Stack & Carson 2003). Van Egmond (1993) has suggested that the aflatoxins detected in milk can be occurred when the animal has been fed with contaminated feed. Since the study has done in a tropical country, due to the high humidity and the tropical temperature there can be a tendency of fungal growth and synthesis of aflatoxins due to moisture absorption property of coconut oil cake.

V. CONCLUSION

Formulated dairy cattle concentrates were comparatively higher in traceability and in compliance with the quality standards, compared to coconut oil cakes.

None of the farmers were using Mix Ration Method to feed their herds. Instead they all used the separate feeding systems.

Feeding frequency and portion sized were comparatively higher when cows are provided with formulated cattle concentrates.

Moisture content of stored coconut oil cake products significantly depend on the storage conditions and may have a greater tendency of fungal growth. Formulated dairy cattle concentrates have comparatively lower tendency to absorb moisture due to improper storage.

VI. RECOMMENDATIONS

Suggestions to farmers: Coconut oil cake users have to follow proper storage practices to avoid moisture absorbance. Farmers need to practice total mixed ration feeding systems that may increase milk performances.

Suggestions to dairy cattle concentrate producers: Addition of product information (manufacturer's details, batch number details, manufactured date and expire date details) and traceability records to the product is a must to gain high quality milk output from farms.

Suggestions for responsible parties: Regular monitoring whether the cattle feed concentrate manufacturers are obeying the Animal Feed (Amended) Act No 15 of 2016 Parliament of the Democratic Socialist Republic of Sri Lanka is important.

To researchers worldwide: Frequent investigation of the quantity, efficiency, quality, handling practices and storage conditions in small scale dairy farms is of utmost importance for any country/community to estimate the development of the dairy industry in the particular country/region.

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REFERENCES

- [1] Animal Feed (Amended) Act No 15 of (2016) Parliament of the Democratic Socialist Republic of Sri Lanka.
- [2] AOAC International. (2019). Official Methods of Analysis 21st ed. Washington DC: Association of official analytical chemists.
- [3] Burkholder, K. M., Guyton, A. D., Mckinney, J. M., & Knowlton, K. F. (2004). The effect of steam flaked or dry ground corn and supplemental phytic acid on nitrogen partitioning in lactating cows and ammonia emission from manure. *Journal of Dairy Science*, 87(8), 2546–2553. [https://doi.org/10.3168/jds.S0022-0302\(04\)73379-2](https://doi.org/10.3168/jds.S0022-0302(04)73379-2)
- [4] Casper, D. P., Schingoethe, D. J., Eisenbeisz, W. A. (1990). Response of early lactation dairy cows fed diets varying in source of nonstructural carbohydrate and crude protein. *Journal of Dairy Science*, 73(4), 1039–1050. DAPH. (2015). Livestock statistical bulletin 2015, 6–17.
- [5] Codex Alimentarius Commission Recommended International Code of Practice – General Principles of Food Hygiene, Amendment (2008).
- [6] Department of Animal Production and Health, Peradeniya, Sri Lanka, Livestock Statistical Bulletin (2015).
- [7] Eastridge, M. L. (2006). Major advances in applied dairy cattle nutrition. *Journal of Dairy Science*, 89(4), 1311–1323.
- [8] Ferland, M. C., Guesthier, M. A., Cue, R. I., Lacroix, R., Burgos, S. A., Lefebvre, D., Wade, K. M. (2018). Effect of feeding system and grain source on lactation characteristics and milk components in dairy cattle. *Journal of Dairy Science*, 1–14.
- [9] Harris, B. J. (Uni of F. (1992). Nutrient requirements of dairy cattle. *Dairy Production Guide, Animal Sci*, 8.
- [10] Hutjens, M. (1996). Practical approaches to feeding the high producing cow. *Animal Feed Science and Technology*, 59(1–3), 199–206.
- [11] IFCN. (2017). The Global Dairy World 2016 / 17, (October).
- [12] Ishler, V. A., Adams, R. S., Heinrichs, A. J., Varga, G. A. (1914). Concentrates for dairy cattle. *Animal Science*.
- [13] Istasse, L., Reid, G. W., Tait, C. A. G., ØRSKOV, E. R. (1986). Concentrates for dairy cows, 15, 167–182.
- [14] Jin, S. G., Li, M., Liu, W., Zhou, Y. (2007). Effect of including different levels of palm kernel cake to dairy cow concentrate on milk production and composition. *Journal of Animal and Feed Sciences*, 566–570.
- [15] Kavanagh, S. (2016). Feeding the dairy cow (Concentrates). *Teagasc Dairy Manual*.
- [16] Kennelly, J. J. (1996). Producing milk with 2.5% fat - The biology and health implications for dairy cows. *Animal Feed Science and Technology*, 60(3–4), 161–180.

[17] Knaus, W. (2016). Perspectives on pasture versus indoor feeding of dairy cows. *Journal of the Science of Food and Agriculture*, 96(1), 9–17.

[18] Kolver, E. S., & Muller, L. D. (1998). Performance and nutrient intake of high producing holstein cows consuming pasture or a total mixed ration. *Journal of Dairy Science*, 81(5), 1403–1411.

[19] Moran, C. A., Morlacchini, M., Keegan, J. D., Warren, H., Fusconi, G., Srl, C., Bonico, S. (2019). Dietary supplementation of dairy cows with a docosahexaenoic acid-rich thraustochytrid, *Aurantiochytrium limacinum*: effects on milk quality, fatty acid composition and cheese making properties. *Journal of Animal and Feed Sciences*, 3–14.

[20] Perera, B., Jayasuriya, M. (2008). The dairy industry in Sri Lanka: current status and future directions for a greater role in national development. *Journal of the National Science Foundation of Sri Lanka*, 36(0), 115.

[21] Samarathunga, J., Jayasinghe, M., Edirisinghe, M., Wijesekara, I., Abeysundara, P., Shafi, A., Farooq, U., Senadheera, S. (2020) A comparative study to deveop calcium, zinc, and antioxidant rich drinking yoghurt products using plant and pharmaceutical ingerdients. *Asian J Agric & Biol Agric*, 1, 8(2), 174–185. <https://doi.org/10.35495/ajab.2019.08.360>

[22] Stack, J., Carlson, M. (2003). NF571 *Aspergillus flavus* and aflatoxins in corn, plant disease. C-18 field crops. Lincoln: Historical Materials from University of Nebraska.

[23] Van Egmond, H. P. (1993). Aflatoxin M₁: occurrence, toxicity, regulation. Mycotoxins in dairy products. In H. P. Van Egmond (Ed.) (pp. 11-54). London: Publishers Elsevier Applied Sicence.

[24] Walker, G. P., Dunshea, F. R., Doyle, P. T. (2004). Effects of nutrition and management on the production and composition of milk fat and protein: A review. *Australian Journal of Agricultural Research*, 55(10), 1009–1028.

[25] Wilkerson, V. A., Glenn, B. P., McLeod, K. R. (1997). Energy and nitrogen balance in lactating cows fed diets containing dry or high moisture corn in either rolled or ground form. *Journal of Dairy Science*, 80(10), 2487–2496.

[26] <https://dairy.ahdb.org.uk/>, AHDB Dairy (2018), world dairy cow numbers, <https://dairy.ahdb.org.uk/resources-library/market-information/farming-data/world-cow-numbers/#.XgyZtkczbIU>

[27] <http://www.fao.org/>. FAO. (2018). Gateway to dairy production and products, <http://www.fao.org/dairy-production-products/production/en/>